DEPARTMENT OF THE NAVY
NAVAL SURFACE WARFARE CENTER
DAHLGREN DIVISION
17320 DAHLGREN ROAD
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IN REPLY REFER TO
10550
Ser J52/4152
MAY 0 2 2005

From: Commander, Dahlgren Division, Naval Surface Warfare Center
To: PM J-AIT
(M. Finley)
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Lorton, VA 22079

Commanding Officer, Naval Ordnance Safety and Security Activity
(N84/C. Wakefield)
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Subj: HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) SAFETY EVALUATION TEST RESULTS FOR THE AUTOMATIC IDENTIFICATION TECHNOLOGY (AIT) III EQUIPMENT

Encl: (1) Hazards of Electromagnetic Radiation to Ordnance Safety Evaluation Test Results for the Automatic Identification Technology III Equipment of Apr 05
(2) Revised Hazards of Electromagnetic Radiation to Ordnance Safety Evaluation Test Plan for the Automatic Identification Technology III Equipment of Apr 05
(3) Radiated Emissions Spectrum Characterization and Spectrum Analysis Plots for the Automatic Identification Technology III Equipment of Apr 05
(4) Recommended Equipment Table for NAVSEA OP 3565 of Apr 05

1. As requested by PM J-AIT, a HERO safety evaluation of the Intermec Model CN2NI IC: 1123A-2011B (with B radio); Model CK31 SN: 31200401260 (with G radio); Model 751G SN: 28400401031 (with B radio); Access Point Model WA22G SN: 33500402066 (with G radio); wireless card SN: WG45000558; and printer item PM4A011000001020 SN: 34400400746 (with G radio) was conducted by the Naval Surface Warfare Center, Dahlgren Division during the period of 3 through 27 January 2005. These devices, hereinafter referred to as "AIT III equipment," have an intentional

radio-frequency (RF) transceiver that can pose concerns from a HERO standpoint.

2. The purpose of the HERO safety evaluation was to determine if any radiated RF emissions from the AIT III equipment are of sufficient magnitude to present a hazard to ordnance. A minimum safe separation distance for the operation of the AIT III equipment in proximity to ordnance is provided based on the findings of the evaluation. Final HERO certification for the AIT equipment is granted by the Naval Ordnance Safety and Security Activity (NOSSA). NOSSA will make a final recommendation regarding HERO certification once it has received your request (under separate correspondence) and reviewed the findings of this evaluation. Certification is mandated by NAVSEAINST 8020.7C to ensure ordnance safety prior to introduction of RF emitters into the fleet.

3. Enclosure (1) presents the detailed test configurations, test methodology, results of the radiated emissions (RE) characterization tests, and the RE spectrum analysis, as well as the conclusions and recommendations based upon those results. Enclosure (2) is the revised HERO safety evaluation test plan, and enclosure (3) contains an RE spectrum characterization and spectrum analysis plots for the subject equipment. Enclosure (4) presents a recommended equipment list for incorporation into the next revision of NAVSEA OP 3565, Volume 2.

4. The PM J-AIT and Intermec on-site representatives were given a written quick-look report upon completion of the evaluation.

5. If there are any questions or comments, please contact Ken N. Huynh, J52, at commercial (540) 653-5660 or DSN 249-5660, or via electronic mail at ken.huynh@navy.mil; or Charles Denham, J52, at commercial (540) 653-3444 or DSN 249-3444, or via electronic mail charles.denham@navy.mil.

DALE W. SISSON, JR
By direction

Subj: HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) SAFETY EVALUATION TEST RESULTS FOR THE AUTOMATIC IDENTIFICATION TECHNOLOGY (AIT) III EQUIPMENT

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Ser J52/4152

HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE

SAFETY EVALUATION TEST RESULTS FOR THE

AUTOMATIC IDENTIFICATION TECHNOLOGY III EQUIPMENT

April 2005

Prepared by:

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Distribution authorized to U.S. Government agencies and their contractors; administrative/ operational use (April 2005). Other requests for this document shall be referred to NSWCDD (J52), Dahlgren, VA 22448-5100.

Enclosure (1)

CONTENTS

HERO SAFETY EVALUATION TEST RESULTS FOR THE AIT III EQUIPMENT

1.0 BACKGROUND

During the period of 3 through 27 January 2005, a Hazards of Electromagnetic Radiation to Ordnance (HERO) safety evaluation was conducted on the Intermec Model CN2NI IC: 1123A-2011B (with B radio); Model CK31 SN: 31200401260 (with G radio); Model 751G SN: 28400401031 (with B radio); Access Point Model WA22G SN: 33500402066 (with G radio); wireless card SN: WG45000558; and printer item PM4A011000001020 SN: 34400400746 (with G radio). These devices [hereinafter referred to as Automatic Identification Technology (AIT) III equipment] contain an intentional radio-frequency (RF) transmitter. As the AIT III equipment was being considered for the tracking of ordnance items, it was considered prudent to evaluate the safety of using this equipment in proximity to ordnance.

The AIT III equipment has intentional transmitters and may be operated as close as 4 inches from ordnance or ordnance components. Therefore, it was considered essential that the safe separation distance between HERO UNSAFE/SUSCEPTIBLE ORDNANCE and operating AIT III equipment be determined.

Safety evaluation test data were gathered for the AIT III equipment and analyzed to determine the potential for the emissions to cause HERO. The evaluation was conducted in accordance with the test plan [included as enclosure (2) for information purposes].

The electrically initiated devices (EIDs) used in ordnance vary considerably (depending upon the application) in terms of the maximum no-fire stimulus (MNFS) that they can withstand before initiating. Reference 1 states that "EIDs in ordnance shall not be inadvertently actuated during or experience degraded performance characteristics after exposure to the external electromagnetic environment (EME) levels of Table 3A for both direct RF induced actuation of the EID and inadvertent activation of an electrically powered firing circuit." It also requires that each EID be categorized as to whether its inadvertent ignition would lead to either safety or performance degradation problems. It further establishes maximum limits of induced current levels of 15 percent of the MNFS for EIDs that may be considered a potential safety concern, and 50 percent of the MNFS for EIDs that may be considered a potential reliability concern.

Since some EIDs may have an MNFS as low as 30 mA, it is essential that the MNFS for ordnance in the area be considered before operating any electronic/electrical equipment or intentional transmitter in proximity to ordnance. If this information is unknown at the time of the operation, it should be assumed that the ordnance in the inventory area contains the most sensitive EIDs (those requiring the lowest MNFS).

2.0 TEST CONFIGURATION

It has been determined that, at the AIT III equipment's intended transmit frequency of 2.4 GHz, an RF signal level of 97 dBμV should be established as the limit for

intentional/unintentional RF emissions from an AIT device. Therefore, the AIT III equipment was exercised, to the extent possible, in all modes of operation and variations in configuration, in an attempt to determine the configuration/mode resulting in the worst-case RF emissions.

2.1 RADIATED EMISSIONS (RE) CHARACTERIZATION

These efforts were conducted prior to a spectrum analysis of the RE from the AIT III equipment. Every effort was used to reduce the potential for emissions from supporting equipment to affect the measurement of emissions from the AIT III equipment. The AIT III equipment was placed in the equipment under test (EUT) rooms, in a shielded anechoic chamber for purposes of measuring REs in the 10 kHz to 100 MHz range, in a reverberation chamber for purposes of measuring REs in the frequency range of 100 MHz to 10 GHz and was exercised manually in the EUT room.

2.2 RE SPECTRUM ANALYSIS

For the RE spectrum analysis, the AIT III equipment was placed on a foam table and operated in the same manner as it was for the RE characterization. However, for this effort, a special antenna test fixture (hereinafter referred to as the fixture) was used. This fixture had been designed and constructed to facilitate the analysis of the RE and RF output signal spectrum characteristics of AIT equipment, and to aid in establishing repeatable measurement distances between the radiating EUT and the tuned receiving antenna. For this reason, the fixture was used to measure the magnitude of the intended output signal of the EUTs, as well as those spurious emissions identified as being a concern during the RE characterization efforts.

3.0 TEST METHODOLOGY

All losses in the measurement system equipment setup (such as cable, connectors, and connector adapter losses) were determined and recorded prior to making any measurements. This was accomplished by substituting a signal generator for the AIT III equipment as the RF signal source and recording the measured loss resulting from all interconnecting cables and connectors to be used between the receive antenna and the spectrum analyzer.

3.1 RE CHARACTERIZATION

For this effort, the AIT III equipment was placed on a foam block in the EUT room, and was operated manually. The specific methodologies used are described in the following subsections.

3.1.1 Anechoic Chamber

In order to obtain the RE characterization of the AIT III equipment in the frequency range of 10 kHz to 100 MHz, it was necessary to employ an anechoic chamber (using modified MIL-STD-461 RE102 techniques), with the AIT III equipment configured as described in paragraph 2.1 above. The RE in the frequency range of 10 kHz to 100 MHz were then

measured, recorded, and analyzed to determine the worst-case emissions in this frequency range and whether the magnitude of the RE presents a potential HERO concern.

3.1.2 Reverberation Chamber

The use of a reverberation chamber and the configuration described in paragraph 2.1 above were considered the most expedient method of obtaining the RE characterization of the AIT III equipment in the frequency range of 100 MHz to 10 GHz. The RE from the AIT III equipment was measured, recorded, and analyzed to determine the worst-case emissions in this frequency range and whether the magnitude of the RE presents a potential HERO concern.

3.2 RE SPECTRUM ANALYSIS

This effort was conducted in the anechoic chamber, guided by the data recorded during the RE characterization and using an antenna test fixture with antennas cut for the specific frequencies to be investigated.

The AIT III equipment was placed at specified distances from the fixture's receive antenna, and was exercised through all modes of operation in such a manner as to shorten the interval between transmissions as much as possible while capturing an accurate portrayal of the maximum amplitude of the emissions or RF output signal voltage envelope. A typical representation of the configuration of the AIT III equipment for this assessment is shown in Figure 1.

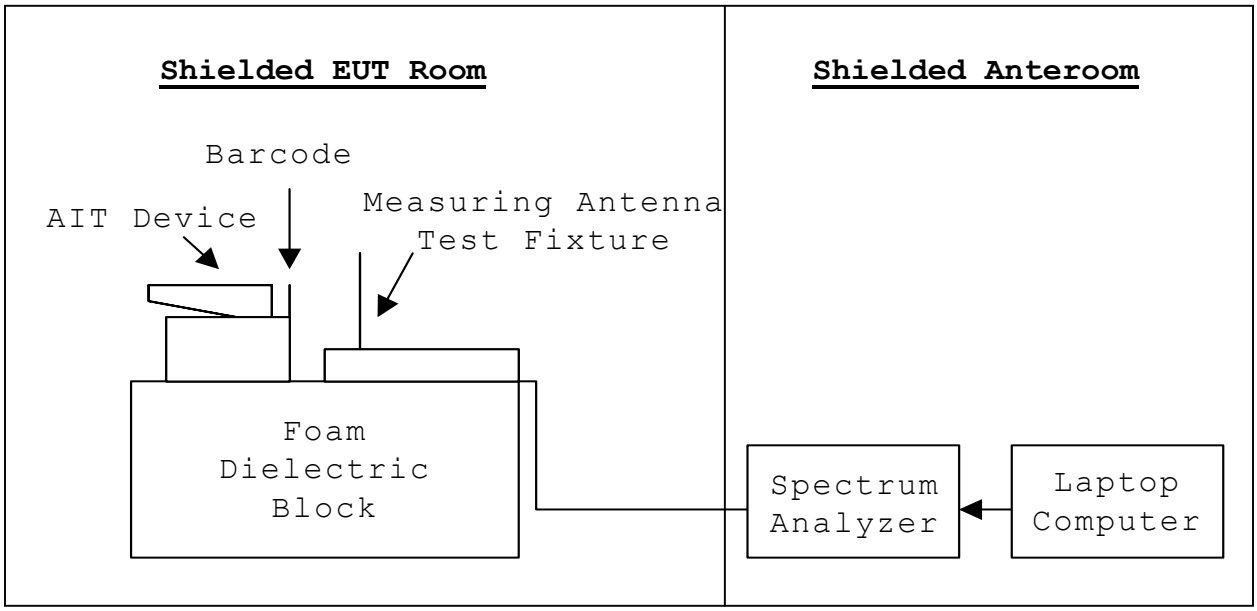

FIGURE 1. RF EMISSIONS MEASUREMENT CONFIGURATION FOR HERO SAFETY EVALUATION OF AIT III EQUIPMENT

4.0 TEST/EVALUATION RESULTS AND DISCUSSION

Since it was not possible for the Intermec on-site representative to provide more than one operational AIT III unit for evaluation, it was not possible to compare several samples of the AIT III equipment and determine which AIT III unit exhibited the worst-case spurious and/or intended RF emissions levels, or select the worst-case units to be used as the test samples for the remainder of the evaluation. Therefore, the following results and recommendations are based on the assumption that the REs from the units evaluated are the highest (intentional or unintentional) levels that will emanate from any AIT III equipment.

4.1 RE CHARACTERIZATION TEST RESULTS

When measured in the reverberation chamber, in the frequency range of 100 MHz to 10 GHz, the most significant RE from the AIT III equipment was found in the unit's intended transmit frequency range at 2.400 to 2.485 GHz. Although the amplitude of spurious RF emissions at frequencies other than the intended transmit frequency were of sufficient amplitude to exceed the applicable MIL-STD-461 RE102 limits, they were not found to be at levels sufficient to present a HERO concern.

The RE characterization effort was then continued in the anechoic chamber, in the frequency range of 10 kHz to 10 GHz. In this frequency range, the AIT III equipment did not exhibit emission levels that were high enough to warrant further investigation from a HERO perspective, with the exception of those in the intended transmit frequency range.

4.2 RF EMISSIONS SPECTRUM ANALYSIS RESULTS

As no significant emissions were observed during the RE characterization (with the exception of those in the intended transmit frequency range), these efforts concentrated on determining if the intended RF output signal transmitted by the AIT III equipment exceeds a level of 97 dBµV at or about 2.4 GHz, and determining the safe separation distances for operation of the AIT III equipment from HERO UNSAFE/SUSCEPTIBLE ORDNANCE.

The intended output level signal levels were found to be as follows:

a. Intermec CN2: 93.430 dBµV at a distance of 6 inches; 92.600 dBµV at 8 inches; and 76.770 dBµV at 1 meter, at 2.400 to 2.485 GHz configured to transmit the data to the access point;

b. Intermec CK31: 91.925 dBµV at a distance of 6 inches; 89.272 dBµV at 8 inches; and 77.599 dBµV at 1 meter, at 2.400 to 2.485 GHz configured to transmit the data to the access point;

c. Intermec 751: 95.599 dBµV at a distance of 4 inches; 88.601 dBµV at 8 inches; and 74.270 dBµV at 1 meter, at 2.400 to 2.485 GHz configured to transmit the data to the access point;

d. Intermec Access Point: 90.934 dBμV at a distance of 6 inches; 88.601 dBμV at 8 inches; and 75.925 dBμV at 1 meter, at 2.400 to 2.485 GHz configured to receive the data;

e. Wireless Card: 94.750 dBμV at a distance of 4 inches; 80.252 dBμV at 8 inches; and 68.426 dBμV at 1 meter, at 2.400 to 2.485 GHz configured to transmit the data to the access point; and

f. Intermec Printer: 95.266 dBμV at a distance of 6 inches; 91.601 dBμV at 8 inches; and 81.600 dBμV at 1 meter, at 2.400 to 2.485 GHz configured to print the transmitted data from the access point.

The RF emissions characteristics are presented in plots J52-4152-01 through J52-4152-18, respectively, in enclosure (3).

5.0 SUMMARY AND CONCLUSION

The intent of this test was to ensure that HERO safety is preserved when any of the AIT III components are used in near-touching proximity to ordnance. That is, the investigation was tailored to provide the recommended safe separation distance between ordnance and a single AIT III device.

It should be noted that, when multiple transmitting devices are simultaneously used in enclosed spaces, such as the interior compartments of U.S. Navy ships and submarines, the aggregate effect on the ambient or volumetric electromagnetic field in those spaces may increase as a result of complex cavity effects.

To date, the AIT III equipment has not been evaluated for electromagnetic compatibility (EMC) when operated with other electrical or electronic equipment on a system, or for the ability to be properly operated when exposed to Department of Defense (DoD) service-use, radiated EMEs. Hence, the AIT III equipment has not yet been demonstrated, from an electromagnetic environmental effects perspective, to be suitable for service use on DoD platforms.

6.0 RECOMMENDATIONS

These recommendations are made with regard to the RE characterization test results for potential effects on other sensitive electronic equipment and the RE spectrum analysis.

6.1 RE CHARACTERIZATION TEST

The results of these tests indicate that care should be exercised to ensure that the AIT III equipment is not operated in proximity to other sensitive electronic equipment; measures should be taken to mitigate the potential effects of the RF emissions from the AIT III equipment on other sensitive equipment.

6.2 RE SPECTRUM ANALYSIS

The results of this assessment indicate that the RF emissions resulting from the operation of the Intermec CN2 (with B radio) when measured at distances of 6 inches or greater; the Intermec CK31 (with G radio) when measured at distances of 6 inches or greater; the Intermec 751 (with B radio) when measured at distances of 4 inches or greater; the Intermec Access Point (with G radio) when measured at 6 inches or greater; the wireless card when measured at 4 inches or greater; and the Intermec printer (with G radio) when measured at 6 inches or greater, are below the emissions levels necessary (97 dBμV) to pose a potential HERO concern.

Therefore, as shown in enclosure (4), the operation of the AIT III equipment should not be considered a hazard to HERO UNSAFE/SUSCEPTIBLE ORDNANCE when operated at the distances stated in the preceding paragraph.

7.0 ADDITIONAL RECOMMENDATIONS

The AIT III equipment has not been subjected to any testing to determine its vulnerability/susceptibility to radiated EMEs. Therefore, the AIT III equipment is not suitable for use in the Army's external radiated EME or the Navy's shipboard EME without first being subjected to and passing radiated susceptibility (RS103) test and evaluation to the requirements of MIL-STD-461, as a minimum.

In addition to the near-touching HERO safety evaluation provided in this report, NSWCDD (J50) recommends that the following be performed prior to use of AIT III devices in/on DoD platforms:

a. Tailored MIL-STD-461E assessments of the EMC of the AIT III equipment when operated with other electrical or electronic equipment in a system to include radiated emissions (RE102) and radiated susceptibility (RS103).

b. Tailored MIL-STD-464A assessment of the electromagnetic vulnerability of the AIT III equipment when exposed to radiated environments produced by other systems, such as above-deck areas onboard Navy ships.

If DoD programs intend to use multiple AIT III devices in enclosed spaces, NSWCDD (J50) recommends that the impact on the ambient electromagnetic field levels in those spaces should be assessed. This assessment may involve performing in-situ measurements of complex cavity characteristics. NSWCDD (J50) has ongoing expertise in assessing aggregate electromagnetic field effects and can provide assistance to DoD programs in making these assessments.

8.0 REFERENCE

1. Department of Defense Interface Standard: Electromagnetic Environmental Effects Requirements for Systems, MIL-STD-464A (DoD), 19 Dec 2002.

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REVISED HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE

SAFETY EVALUATION TEST PLAN FOR THE

AUTOMATIC IDENTIFICATION TECHNOLOGY III EQUIPMENT

April 2005

Prepared by:

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Enclosure (2)

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REVISED HERO SAFETY EVALUATION TEST PLAN FOR THE AIT III EQUIPMENT

1.0 GENERAL

As equipment using complex state-of-the-art technology in its design is developed and more commercial-off-the-shelf (COTS) equipment is acquired for use in military electromagnetic environments (EMEs), it becomes much more important that the equipment/systems are thoroughly tested to ensure compatibility with their intended operational EMEs.

This test plan is being provided for the HERO safety evaluation testing of the Intermec Model CN2NI IC: 1123A-2011B (with B radio); Model CK31 SN: 31200401260 (with G radio); Model 751G SN: 28400401031 (with B radio); Access Point Model WA22G SN: 33500402066 (with G radio); wireless card SN: WG45000558; and printer item PM4A011000001020 SN: 34400400746 (with G radio) (herein after referred to as the "AIT III equipment"). The AIT III equipment is intended for use in tracking/inventory of ammunition, ordnance containers, or pallets of ordnance utilizing portable battery-powered bar code scanning devices. The AIT III equipment is intended for use in ordnance storage, assembly, and production areas. Therefore, any radio-frequency (RF) emissions from the AIT III equipment are a concern from an electromagnetic compatibility (EMC) and a Hazards of Electromagnetic Radiation to Ordnance (HERO) perspective.

2.0 EQUIPMENT REQUIRED FOR TESTS

The equipment required for testing includes the following:

a. The Intermec Model CN2NI IC: 1123A-2011B (with B radio); Model CK31 SN: 31200401260 (with G radio); Model 751G SN: 28400401031 (with B radio); Access Point Model WA22G SN: 33500402066 (with G radio); wireless card SN: WG45000558; and printer item PM4A011000001020 SN: 34400400746 (with G radio);

b. Bar code labels, containing sufficient information to maximize, to the greatest extent possible, the scanning and transmitting time of the of the AIT III equipment;

c. All software, operating instructions, docking station, battery packs, power supplies, battery chargers, and any other ancillary equipment which may be necessary for the operation of and/or monitoring the performance of the above equipment; and

d. A person who is thoroughly familiar with the hookup and operation of the AIT III equipment on-site to assist with system setup and possible failure analysis.

3.0 TEST ENVIRONMENTS

The AIT III equipment may be subjected to testing and evaluation to the radiated emission (RE102) test requirements of MIL-STD-461E. The RE102 limits to be observed are depicted in MIL-STD-461E Figure RE102-2, in the frequency range of 10 kHz - 10 GHz. If conducted, the RE102 test results will be used to determine the amplitude and bandwidth of potential emissions from the AIT III equipment, and the potential for other sensitive electronic systems to be affected by emissions from the AIT III equipment. The output signal spectrum characteristics of the AIT III equipment will also be analyzed to determine the safety of operating the AIT III equipment at distances of 4 and 12 inches from HERO UNSAFE and HERO SUSCEPTIBLE ORDNANCE.

The REs and intended output signal levels from the AIT III equipment will also be measured at various distances to determine the safe separation distances for operation of the AIT III equipment from HERO UNSAFE or HERO SUSCEPTIBLE ORDNANCE.

If conducted, the test environments and/or test configuration requirements of MIL-STD-461/462 may be modified at the discretion of the test engineer, based on the intended operational configuration of the equipment under test and the data obtained at the time of testing.

4.0 TEST METHODOLOGY

The AIT III equipment will be set up to operate as it would in its intended operational EME. During the test, care will be taken to assure that equipment components not under test are isolated from the test EME. Field fixes will be installed and evaluated, if appropriate, as test time permits.

The detailed test/evaluation methods will be established on-site at the time of the tests, and the detailed test methodology will be delineated in the test report.

5.0 REPORTING

A quick-look report (oral or written) will be issued within 72 hours of completion of the test. A detailed report will be submitted within 90 days of test completion.

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RADIATED EMISSIONS SPECTRUM CHARACTERIZATION

AND SPECTRUM ANALYSIS PLOTS

FOR THE

AUTOMATIC IDENTIFICATION TECHNOLOGY III EQUIPMENT

April 2005

Prepared by:

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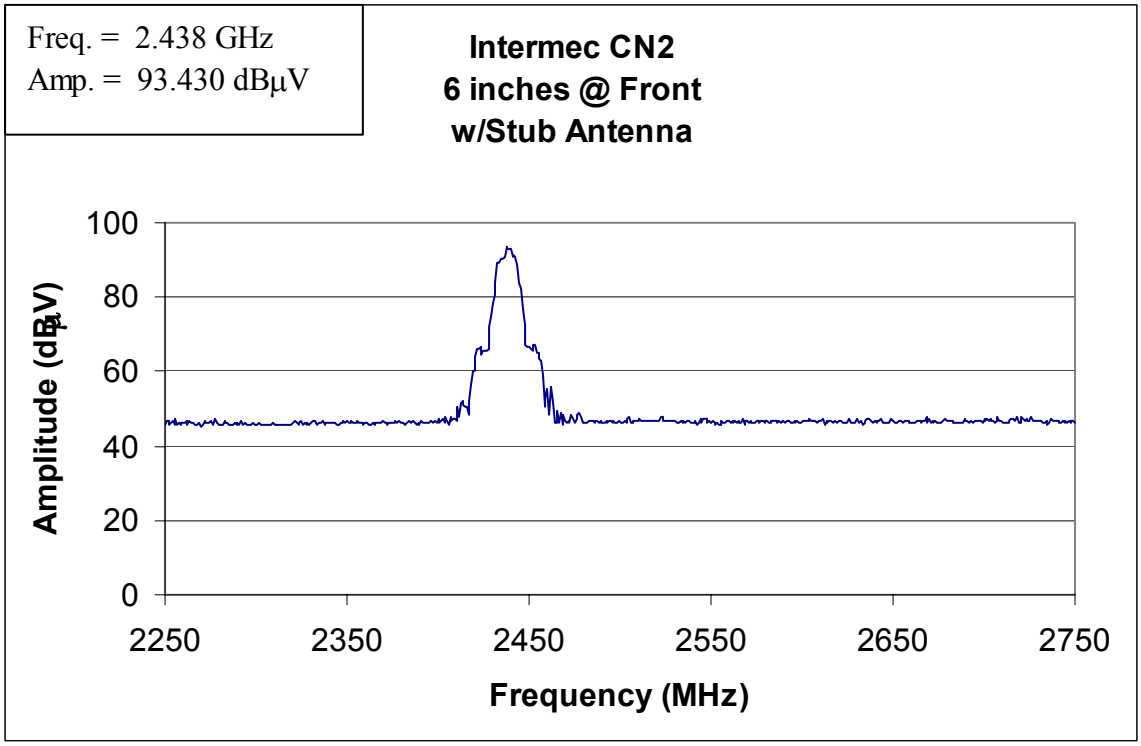
Enclosure (3)



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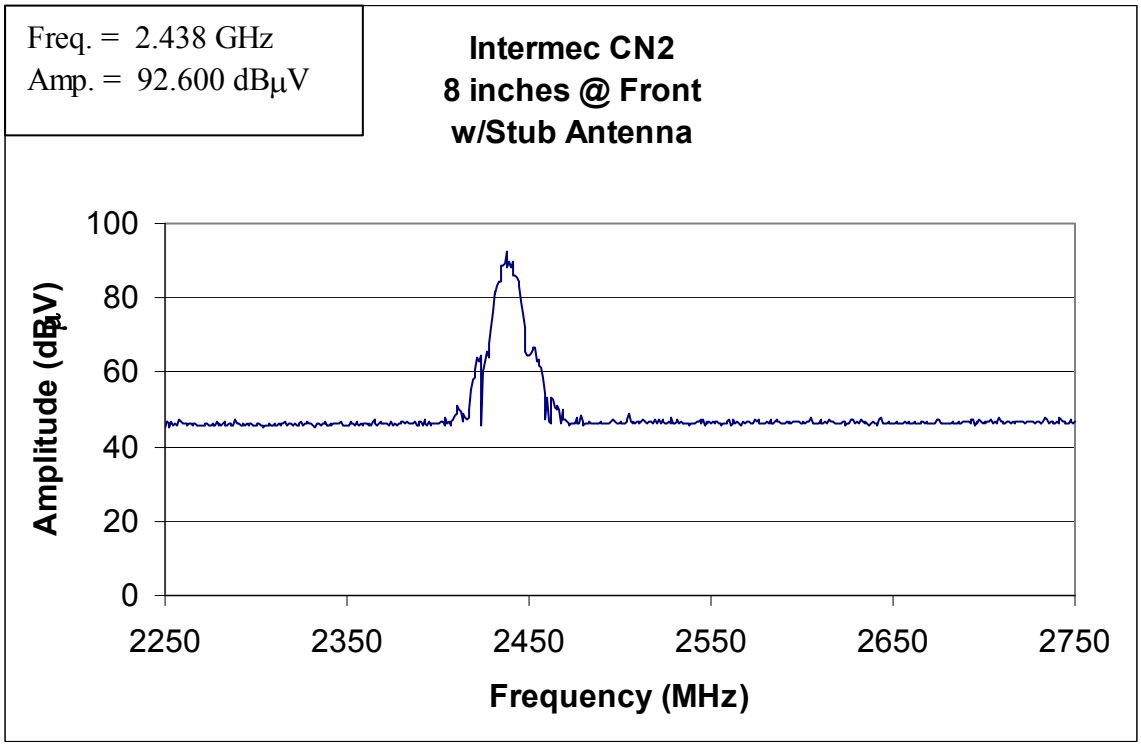

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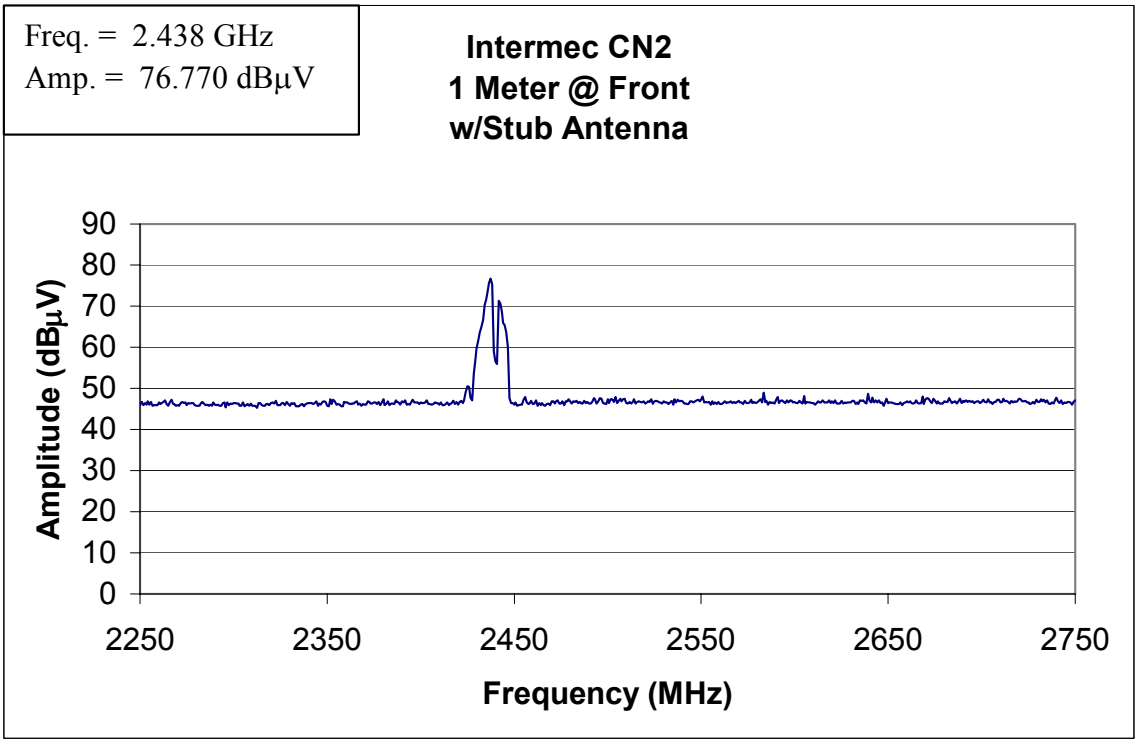

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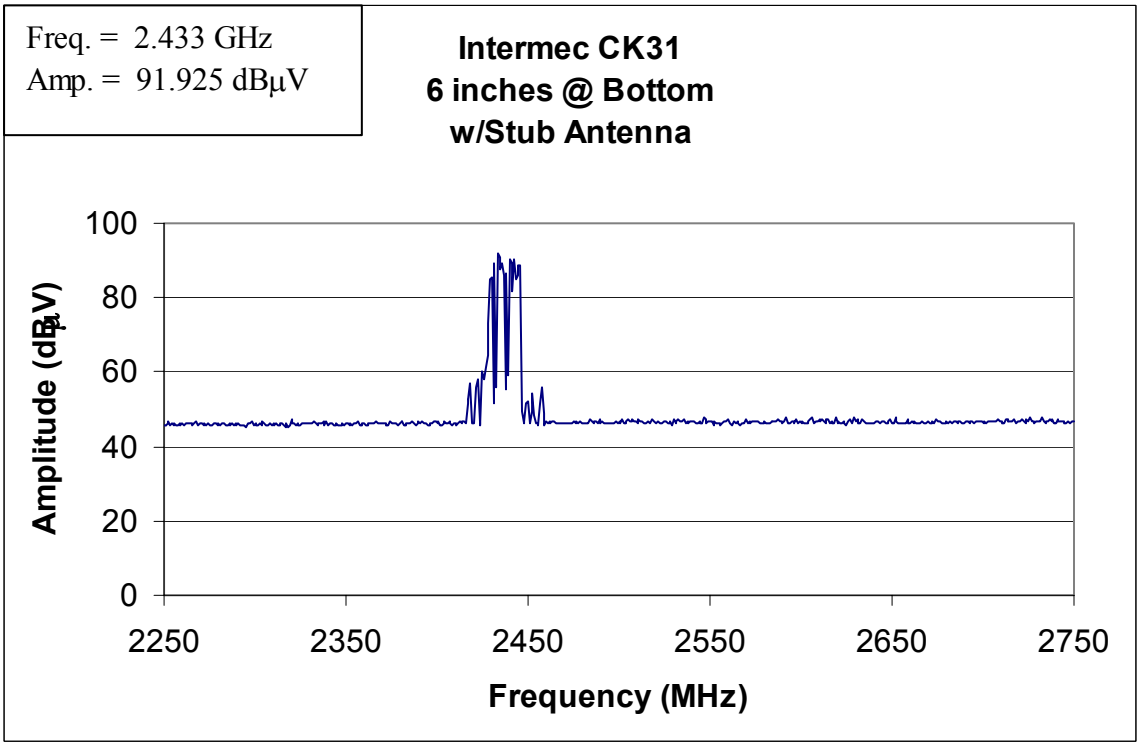

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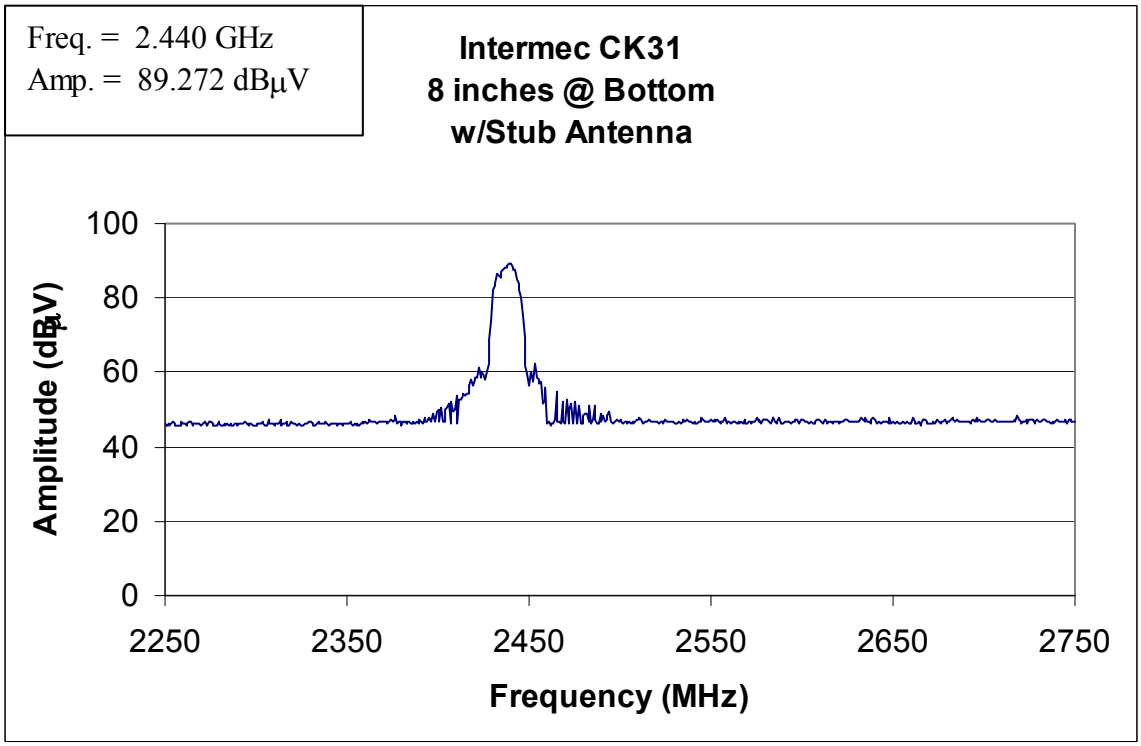

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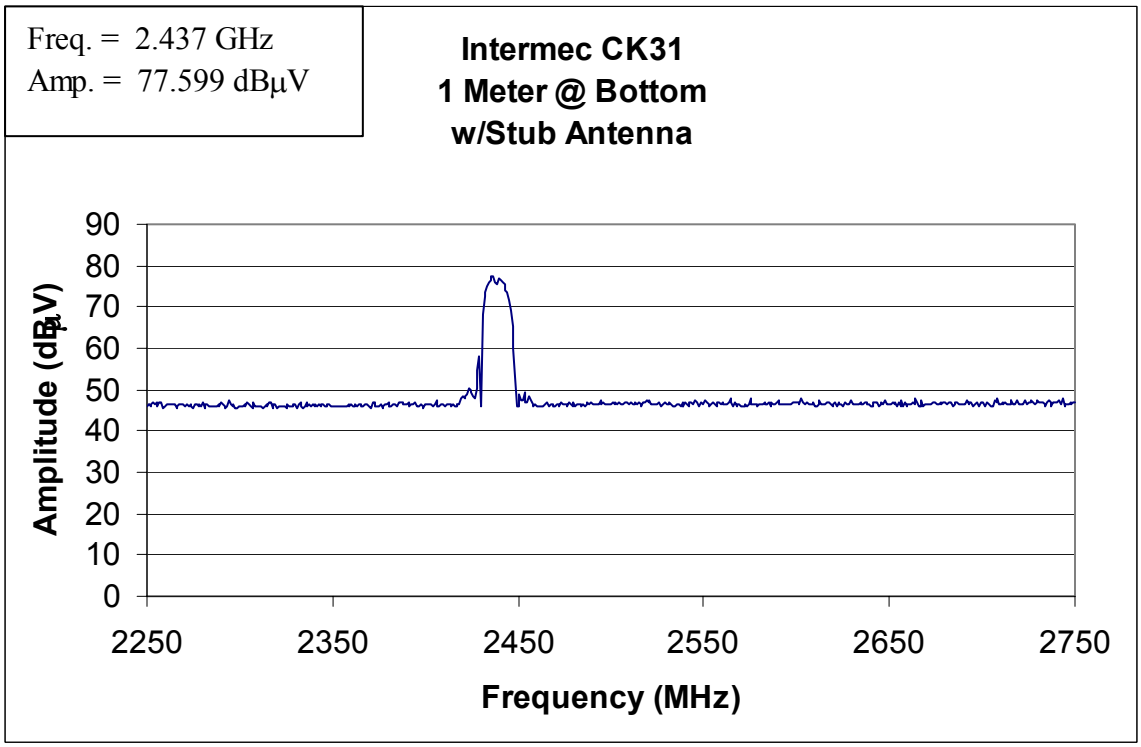

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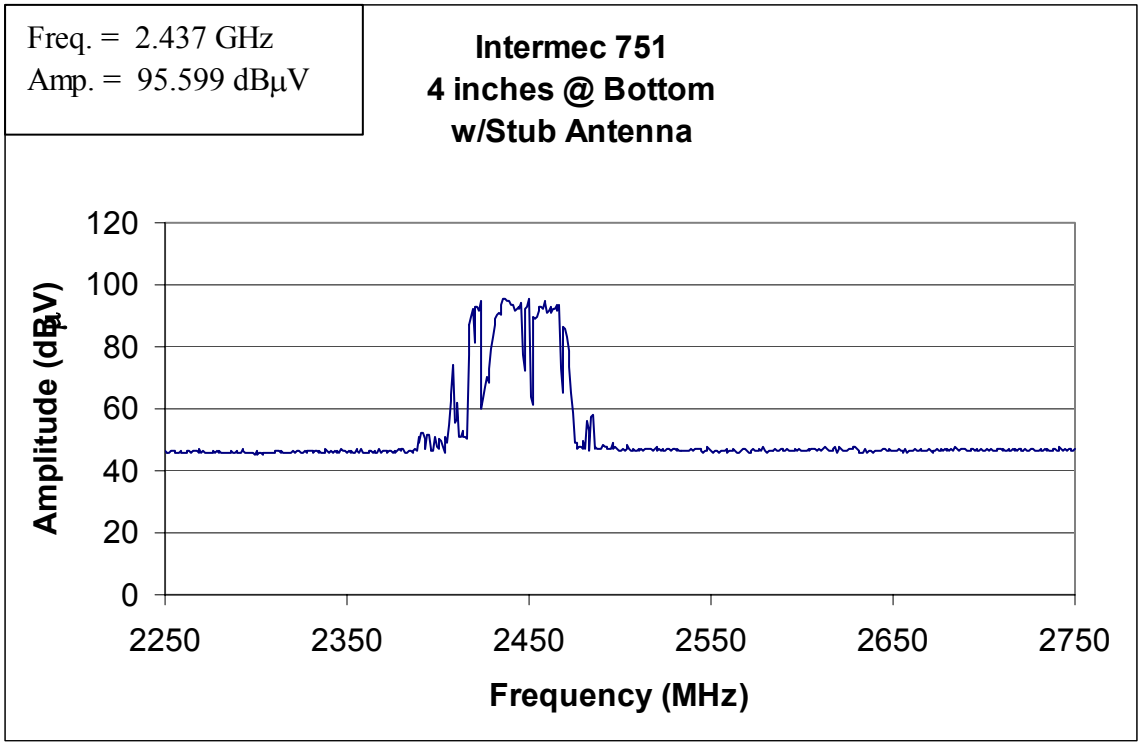

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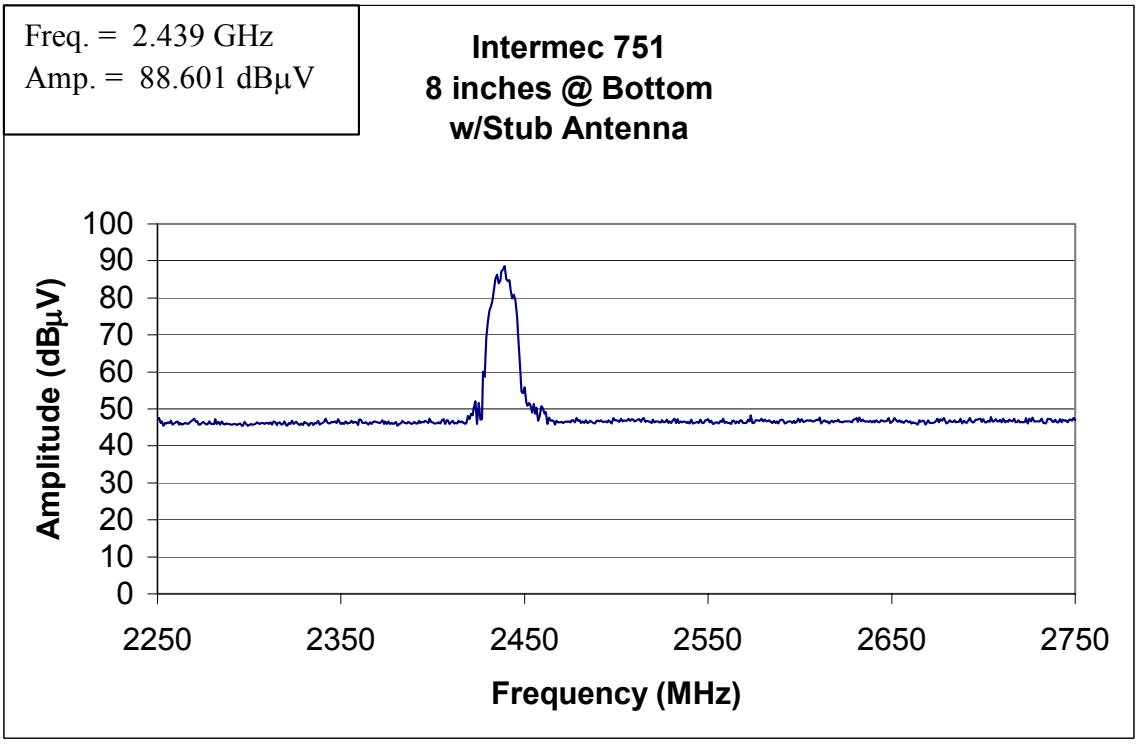

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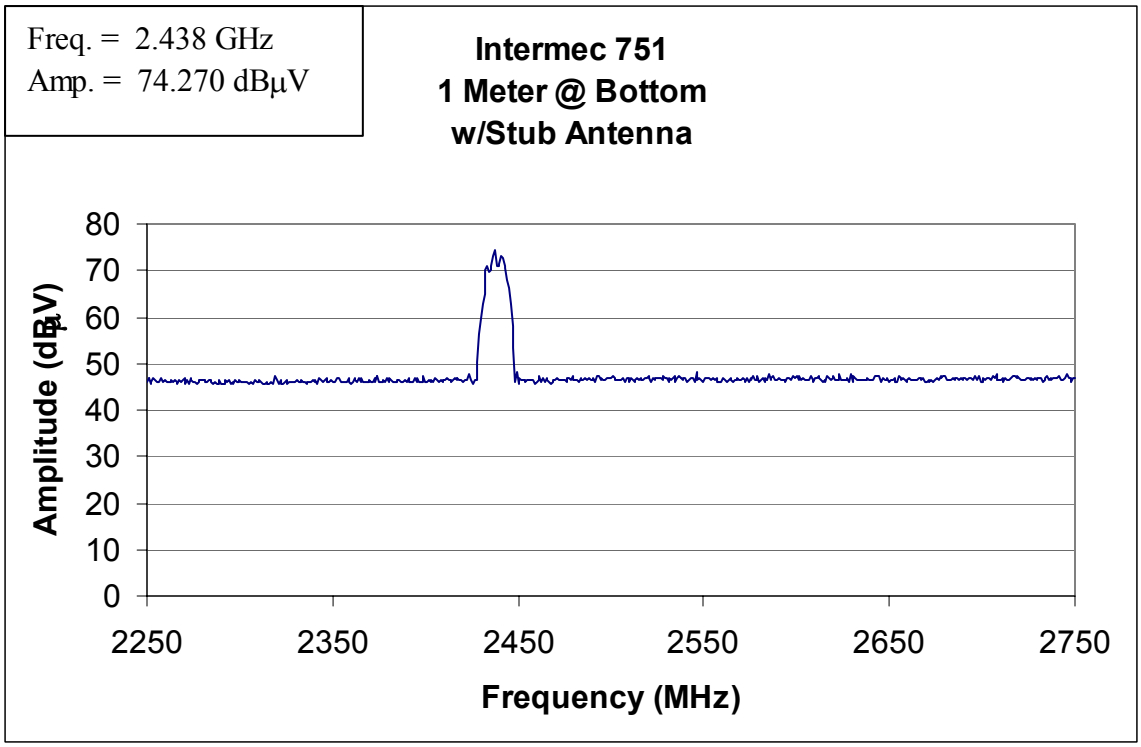

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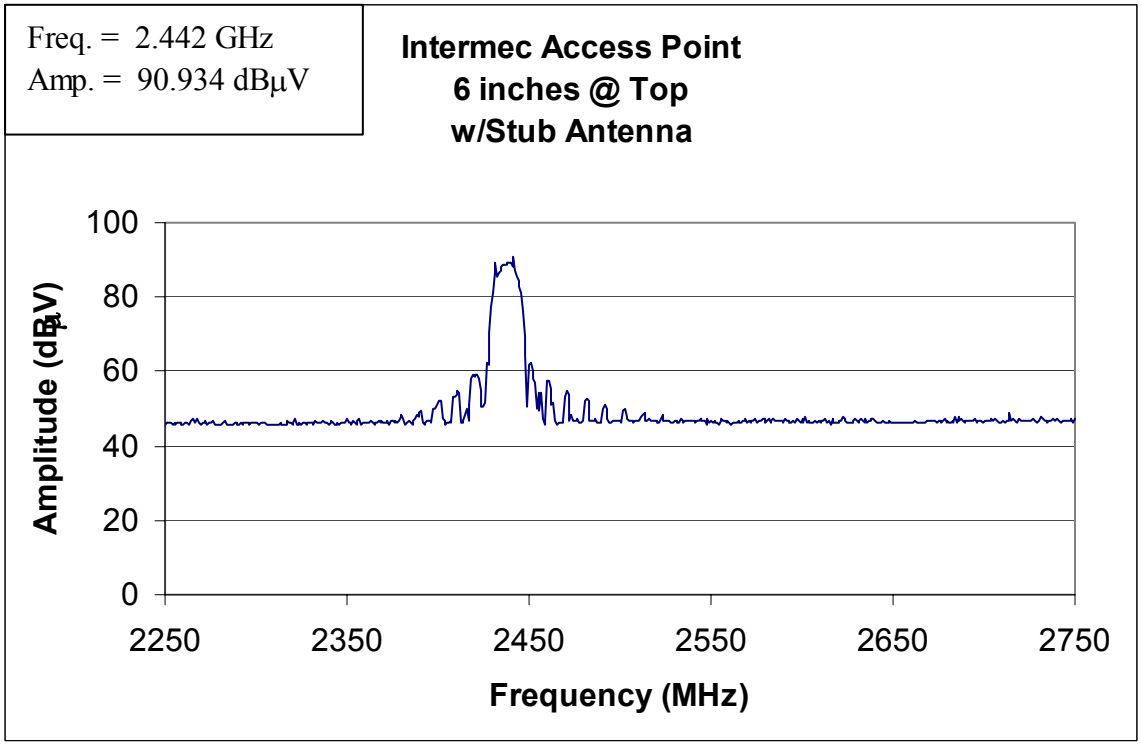

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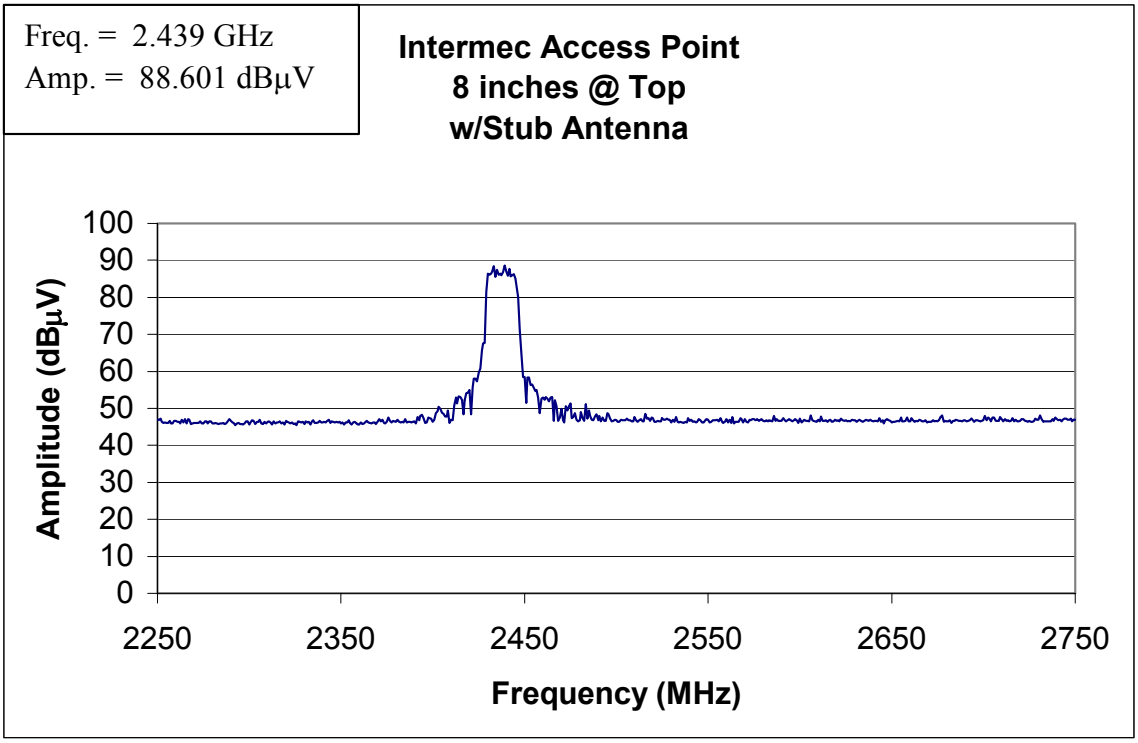

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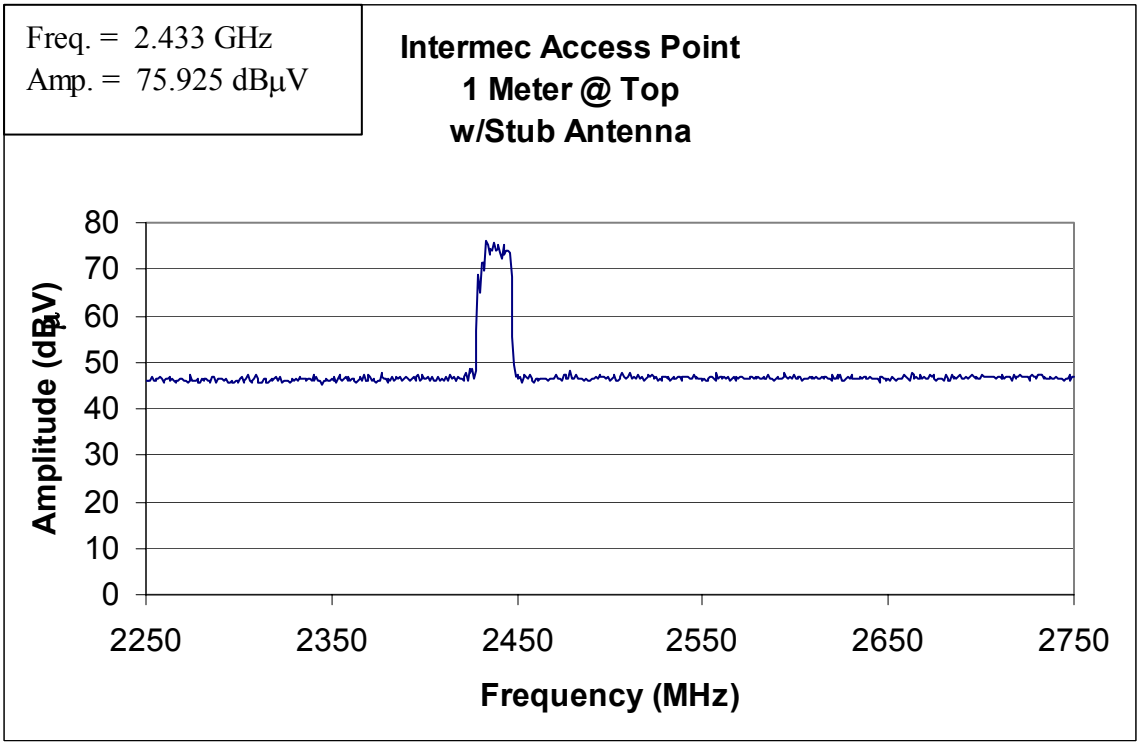

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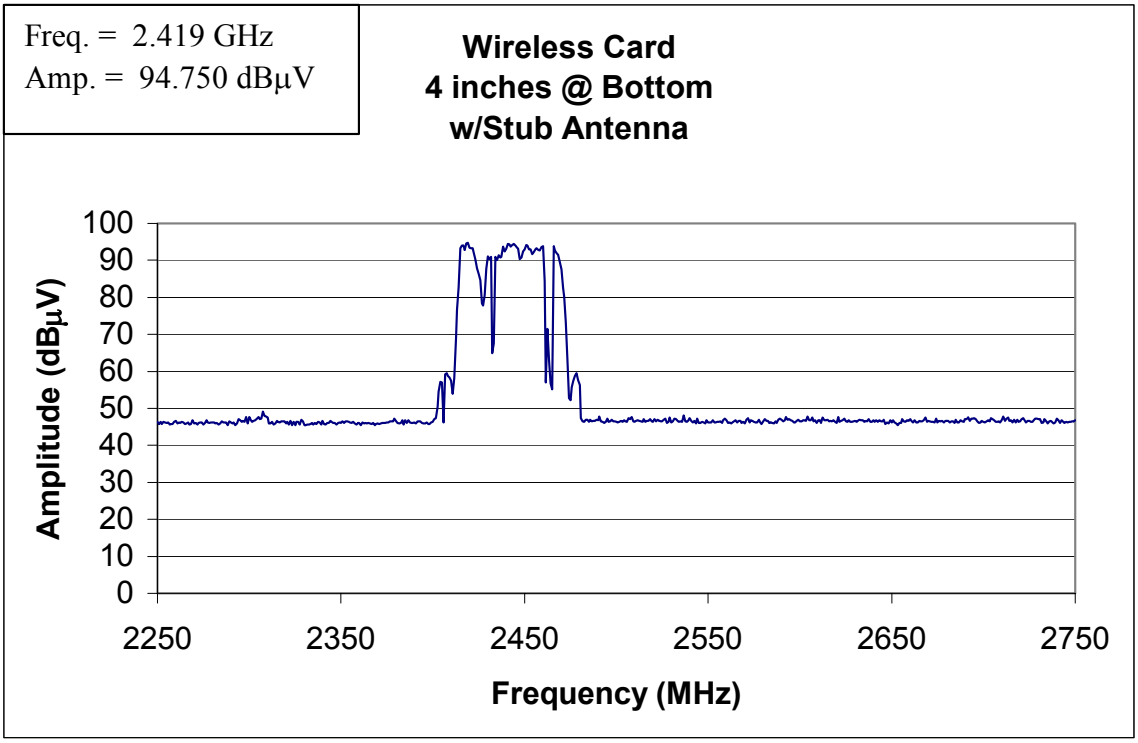

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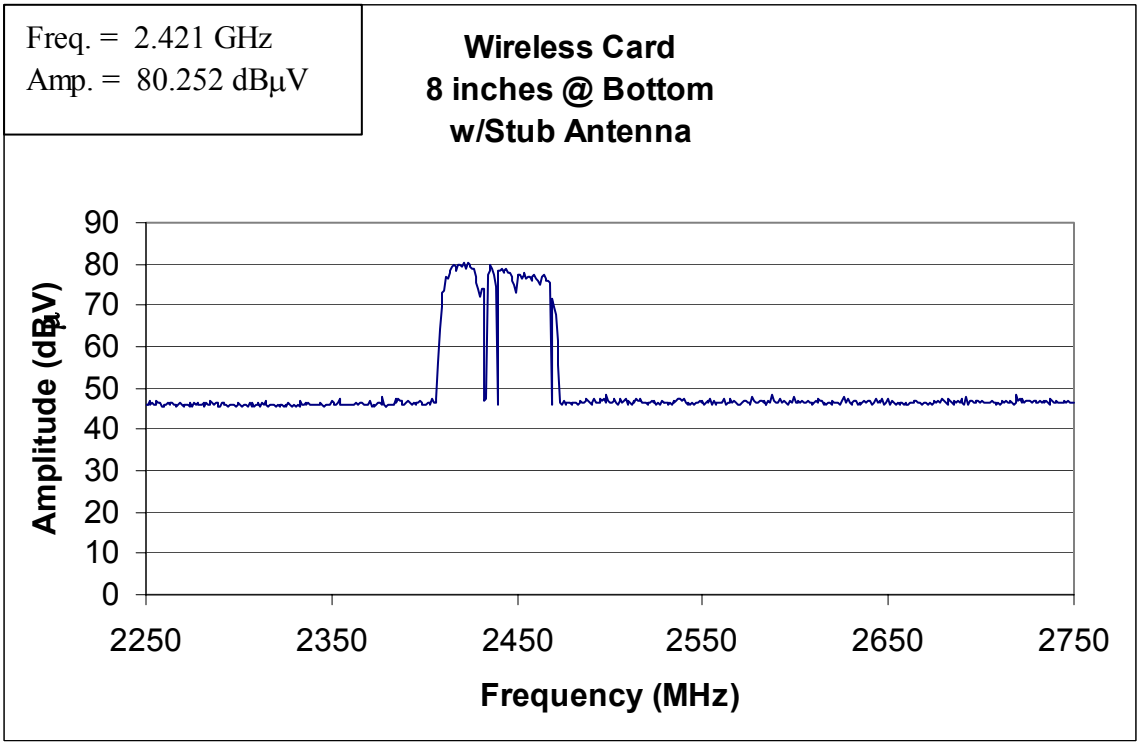

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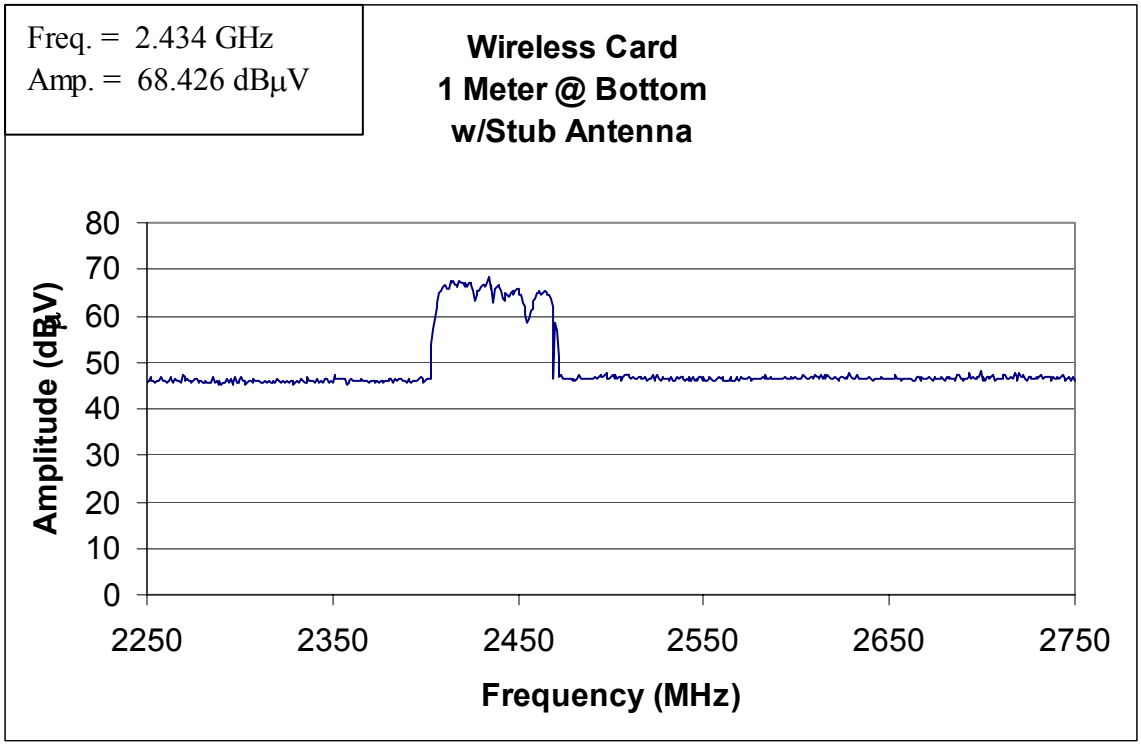
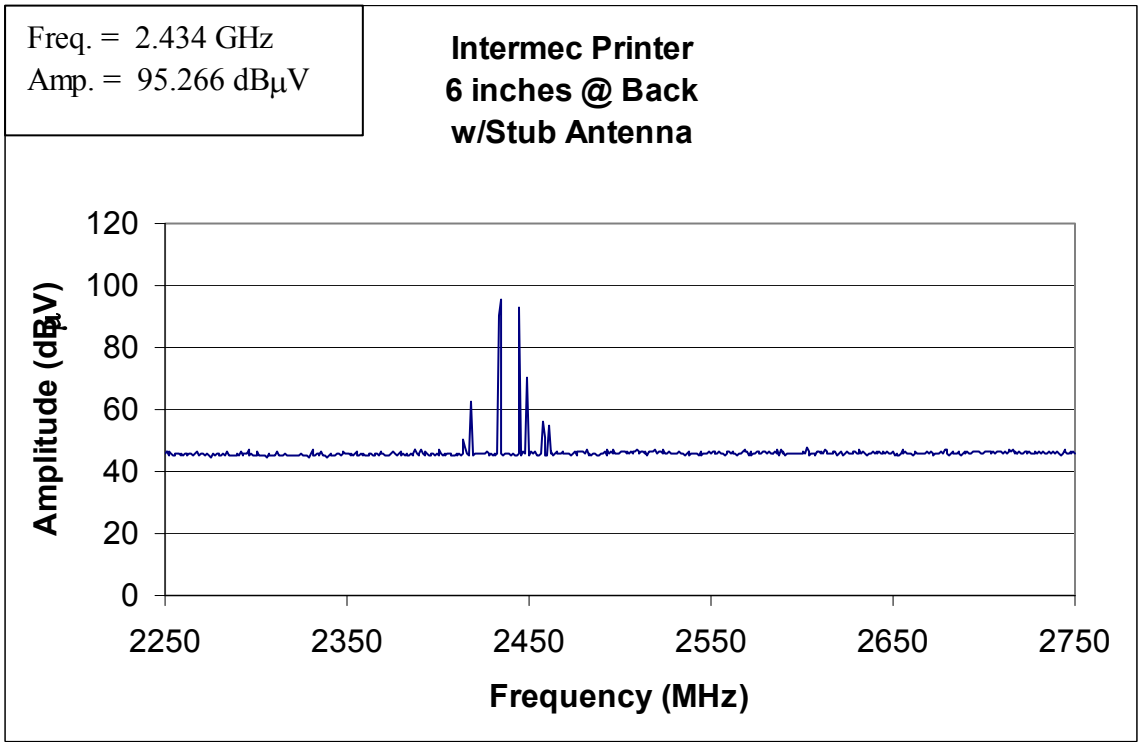
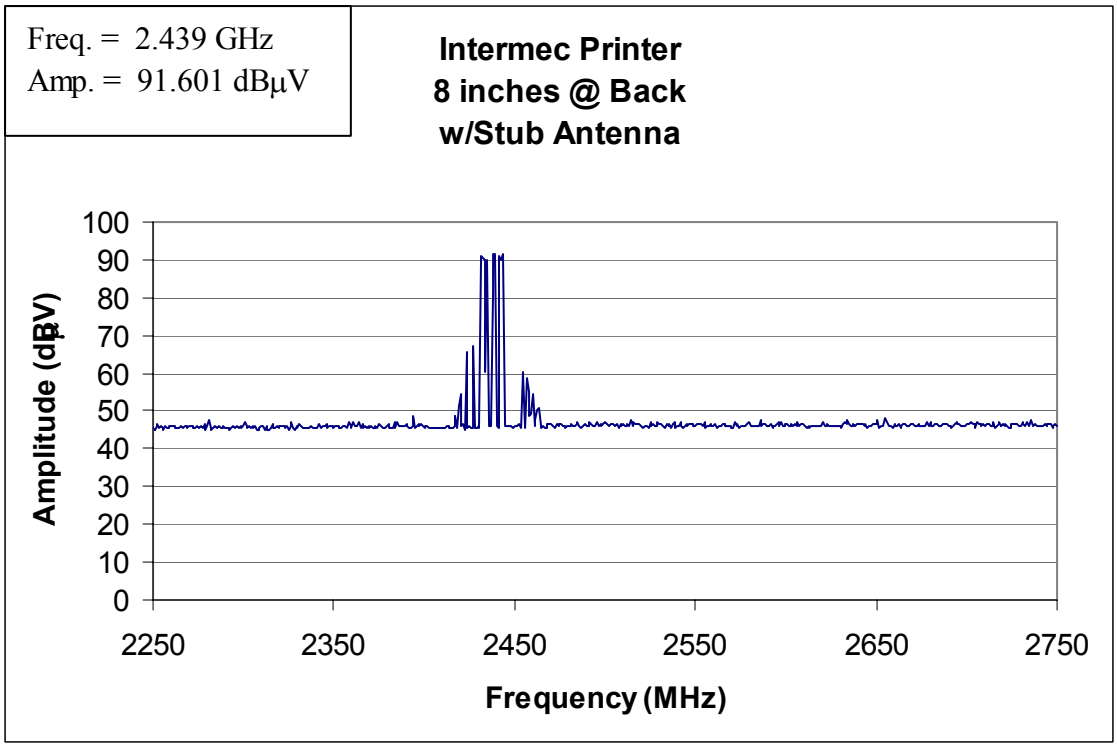


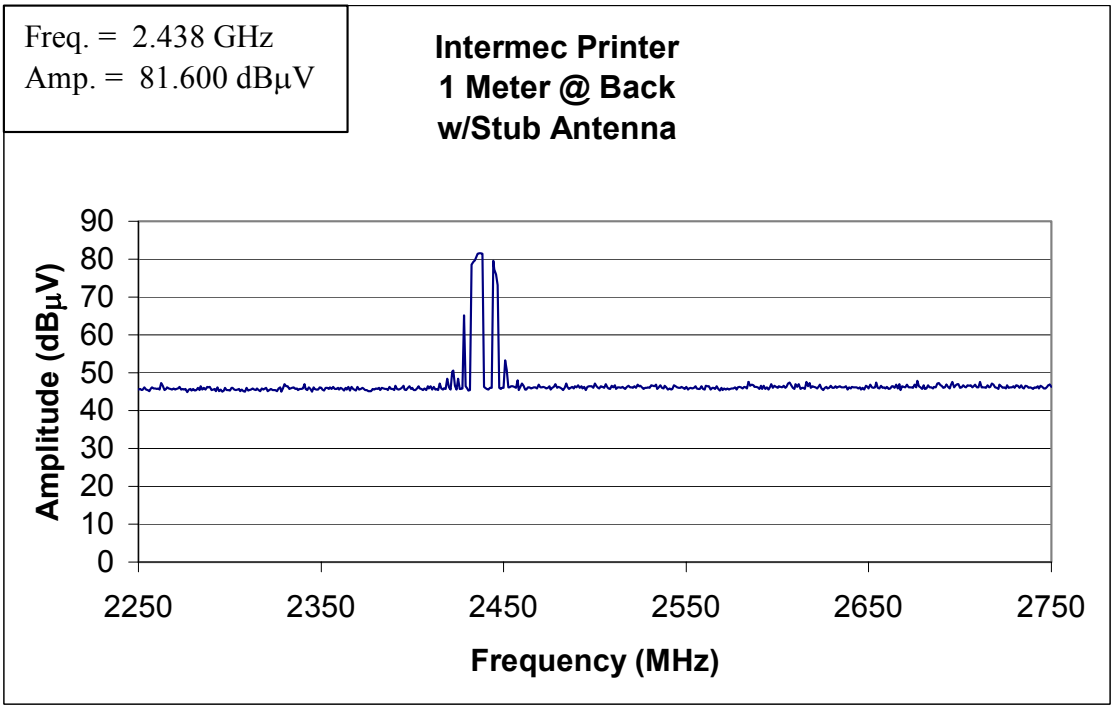
J52-4152-15



J52-4152-16



J52-4152-17



J52-4152-18

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RECOMMENDED EQUIPMENT TABLE FOR NAVSEA OP 3565

April 2005

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Enclosure (4)

RECOMMENDED EQUIPMENT TABLE FOR NAVSEA OP 3565

Date Tested	Unit Nomenclature	Model # / Serial #	RF Transmit Power (mW)	Transmit Frequency (MHz)	Safe Distance (inches/feet)*
Jan 27, 2005	Intermec CN2	IC:1123A-2011B	100	2400-2485	6/0.5
Jan 27, 2005	Intermec CK31	31200401260	50	2400-2485	6/0.5
Jan 27, 2005	Intermec 751G	28400401031	100	2400-2485	4/0.33
Jan 27, 2005	Intermec Access Point WA22G	33500402066	63	2400-2485	6/0.5
Jan 27, 2005	Wireless Card	WG45000558	50	2400-2485	4/0.33
Jan 27, 2005	Intermec Printer PM4A011000001020	34400400746	100	2400-2485	6/0.5

* These safe separation distances apply to all HERO ordnance classifications.